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(54) STRETCHABLE NON-WOVEN POLYAMIDE SHEET

(71) We, UNITIKA, LIMITED, a Japanese Company, of No. 50, Tikashi-hon-Cho 1-Chome, Amagasaki-Shi, Osaka, Japan, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a stretchable non-woven sheet composed of fine denier continuous composite filaments of polyamide having helical crimps, and to a process for producing such non-woven sheet.

Knitted fabrics and stretchable woven fabrics such as woven fabrics made from textured yarns are known for their high stretchability and deformation recovery. They have, however, found only limited applications because of the high cost of their production and their anisotropic dynamic properties. At one time is was though that, since non-woven fabrics were cheap and had no directionality, the desired properties would be obtained if stretchability were imparted thereto. However, non-woven fabrics made of staple fibres produced by a conventional method such as the dry method or wet method cannot be processed by any means into a soft and drapable product, perhaps because the constituent fibres are fixed at the points of bonding. Such non-woven fabrics in fact have far inferior stretchability and deformation recovery to those of the above-mentioned knitted fabrics and stretchable woven fabrics.

Non-woven fabrics prepared from continuous filaments, which have been developed recently, have fewer points of bonding than the non-woven fabrics obtained by the conventional techniques and the relative movability of the constituent filaments is superior. Thus, such fabrics are considered suitable as sheet materials having superior stretchability and deformation recovery; especially those obtained from composite filaments having helical crimps possess good stretchability and feel.

Investigations of various fibrous materials to ascertain which would impart these sheet properties to the greatest extent show that polyamides such as Nylon 6 or Nylon 66 which have both softness and superior dimensional stability are most promising. Since the conventional composite polyamide fibres contain a copolyamide as at least one component, non-woven cloths made from them have poor crimp elasticity and very poor crimp recovery. The work of the present inventors has led to the discovery that this defect can be remedied by using homopolyamides as the constituents of the composite fibres. However, with such components, good crimps are not developed under ordinary conditions, and it is impossible to produce non-woven fabrics from such composite fibres with commercial feasibility. In view of this situation, extensive work has been conducted on a method for producing stretchable non-woven fabrics of polyamides, and has finally led to the present invention.

According to this invention we provide a stretchable polyamide non-woven sheet comprising looped, continuous composite filaments composed of at least two different homopolyamides or homopolyamide mixtures each forming a distinct phase conjugated in a side-by-side or eccentric core-and-sheath configuration along the length of the filaments which are mutually entangled and have the following characteristics:

1) a denier of not more than 2 denier
2) a residual elongation of not more than 100%;
3) an average of at least 20 helical crimps per inch with an average helical radius of from 0.1 to 0.5 mm; and
4) loops such that when a section of length a is defined at any position along any individual filament, the ratio c, of the intrinsic length b of said filament in said section to

the length a fulfils the following criteria:

(1) when $a=5$ mm, the probability of $c \geq 3$ is 20% or less,

and

(2) when $a=20$ mm, the probability of $c \leq 2$ is 60% or more.

One embodiment comprises a stretchable polyamide non-woven sheet having a large amount of three-dimensionally interlaced structure, which is obtained by subjecting the above-mentioned stretchable polyamide non-woven sheet to at least 50 punchings/inch^2 by such means as needle-punching or fluid-punching; and a stretchable polyamide non-woven sheet in which the filaments are also bonded at bonding point in addition to being entangled and which is obtained by uniting the individual filaments of either of the above-mentioned two types of non-woven sheet by one or more bonding treatments selected from adhesive-bonding, embossing and stitch bonding.

The stretchable polyamide non-woven sheet of this invention is produced by a method which comprises co-spinning at least two homopolyamides or polyamide mixtures in a side-by-side or eccentric core-and-sheath configuration to form composite filaments, taking up the spun composite filaments so formed at a rate of at least 1,500 metres/min under conditions such that the filaments each have a denier of not more than 2 and a residual elongation of not more than 100%, relaxing the filaments by a pneumatic stream and depositing them on a receiver under conditions such that the continuous filaments are entangled on said receiver and thereby forming a bulky web, and allowing the web to stand, or heat-treating the web, in the relaxed state to develop fine and firm secondary crimps, thereby forming a sheet in which the continuous filaments have at least 20 helical crimps per inch with an average helical radius of 0.1 to 0.5 mm. Non-woven sheets having additional properties can be produced by subjecting the above sheet to the various known uniting and bonding treatments described above.

The non-woven sheets of this invention are very cheap to produce and have reduced directionality as compared with the conventional stretchable woven fabrics or knitted fabrics, and possess soft hands and good drapability as well. Since the non-woven sheets of this invention have far superior stretchability and deformation recovery to the conventional non-woven sheets and exhibit a high tensile strength and tear strength two or three times as high as those of conventional non-woven sheets, they are useful, for example, as artificial leather, drape, and suede finishing cloth substitute by making the most of these properties.

As previously stated, the non-woven sheet of this invention is composed of homopolyamides. The homopolyamides include all homopolymers or aliphatic, alicyclic and aromatic polyamides. Melt-spinnable aliphatic polyamides such as Nylon 6, Nylon 66 or Nylon 4 are especially effective The superiority of these homopolyamides as materials for the production of the stretchable non-woven sheets is ascribed to the fact that they have high tenacity, a relatively low Young's modulus, and good dimensional stability and heat-setting properties. Especially, crimped composite filaments of homopolyamides have far superior crimp elasticity. Each of the composite filaments formed from at least two of the homopolyamides described above has a structure in which the constituent polymers form two or more distinct phases, and these phases are arranged along the length of the filament (in the direction of the fibre axis) in an eccentric side-by-side or core-and-sheath configuration. Each of these components of the composite filament may consist of a mixture of the same or different homopolymers.

When two or more homopolymers of the same kind but having different degrees of polymerization are used to form each phase of the same composite filament, it exhibits good spinnability and a good capability for being taken up by a pneumatic stream, and the resulting composite filament has a superior crimp elasticity and crimp recovery. Furthermore, no separation is observable between the combined components of the composite filament. Nylon 6 and Nylon 66 are valuable for practical purposes as chief constituents of at least one component of the composite filament. These polymers are cheap, and those of various degrees of polymerization are being produced on a large scale. Furthermore, they are superior in the above-mentioned properties.

The preparation of continuous composite filaments can be performed by using a known melt-extruding apparatus and a known co-spinning spinneret. The spun filaments are then drafted and taken up by a rotating roller or a high speed pneumatic stream. At this time, the filaments are cooled and attenuated, and subjected to a drawing action involving substantial molecular orientation. At the same time, this step results in imparting latent crimpability to the filaments. Since, however, a drafting force surpassing the crimping force acts on the filaments, crimps are hardly developed. The rate of take-up of the filaments is more than 1,500 metres/min, preferably more than 2,000 metres/min, and the drafting should be performed so that the filaments taken up each have a residual elongation of not more than 100% and a denier of not more than 2. Residual elongation is measured in accordance with Japanese Industrial Standard L1070, 5.1.1. When the take-up speed is less than 1,500 metres/min, the

residual elongation of the filament is in excess of 100%, or the denier of the filament exceeds 2, the filaments do not exhibit satisfactory ability to develop latent crimps.

The rate of filament take-up referred to herein is defined by the following equation:

$$\text{Take-up rate (metres/min)} = \frac{\text{Amount of extrusion per monofilament (g/min)} \times 9000}{\text{Denier of a monofilament constituting the sheet}}$$

The filaments which have been taken up at high speed are forwarded downwardly by a pneumatic stream, and deposited on a receiver. At this time, the filaments are relaxed, being unsupported in space, and develop crimps. It should be noted however that it is not appropriate to develop the crimps completely by abrupt relaxation, as will be described later on. In other words, although the filaments have high latent crimpability and can develop fine and strong crimps under no tension, it is preferred that, at this stage, the crimps are not developed completely, but are confined to loose, slight crimps. The crimps developed at this stage are defined as primary crimps. When the take-up operation is carried out by rotating rollers, the filaments are forwarded by means of a pneumatic ejector located under the rollers. Otherwise both the take-up operation and the forwarding operation are continuously performed using a pneumatic ejector. In any case, the jet stream ejected from the pneumatic ejector is used as a forwarding medium.

The outline of this procedure will now be described with reference to the accompanying drawing in which:

Figures 1 (A) to (D) each diagrammatically show an embodiment of a method in accordance with this invention;

Figures 2 (a) and (b) are rough sketches of the state of continuous filaments being laid down on a receiver, Fig. 2 (a) showing a poor example of laydown, and (b) showing a good example of laydown;

Figure 3 is a longitudinal section of one embodiment of a pneumatic ejector used in the method of this invention; and

Figure 4 illustrates an arrangement of the individual filaments in the non-woven sheet of this invention, and the method of defining a certain section to evaluate the degree of crimping.

Fig. 1 (A) illustrates an embodiment where the spun filaments are taken up at high speed using a rotating roller 2, and then forwarded and deposited by means of a pneumatic ejector 3; Fig. 1 (B) an embodiment where the spun filaments are further drawn between a first-stage roller 2 and a second stage rotating roller 2′, forwarded pneu- and then deposited; Fig. 1 (C) and (D) cases where the spun filaments are taken up, forwarded by pneumatic stream, and deposited by an air ejector only. In the Figures, the reference numeral 1 represents a spinning head; 2 a first (or only) rotating roller; 2′ a second rotating roller; 3 a pneumatic ejector, 3′ a circular tube for compensating the spinning distance; 3″ a circular tube for compensating the laydown distance; 4 a deposit surface consisting of an endless wire belt; and 5 an air suction device.

Relaxation proceeds gradually in the space lying between the point at which the continuous filaments have just been ejected by the pneumatic ejector and the receiver. In order that the composite filaments shall develop good crimps and the spinning operation may be continued in a stable condition for prolonged periods of time, it is essential to select a suitable degree of polymerization for each component of the composite filament and the weight proportion of that component. For example, when a bi-component continuous composite filament is composed of the same two polymers but having different degrees of polymerization (such as Nylon 6 or Nylon 66), the intrinsic viscosities and weight proportions of the two components should be selected within the ranges defined by the following parameters:

$$1.10 \leqq |\eta|_L \leqq 1.40;$$

$$1.10 \leqq \frac{|\eta|_H}{|\eta|_L} \leqq 1.40; \text{ and}$$

$$0.3 \leqq \frac{W_H}{W_L} \leqq 3,$$

wherein

$[\eta]_H$ is the intrinsic viscosity of a high viscosity component, $[\eta]_L$ is the intrinsic viscosity of a low viscosity component, W_H is the weight % based on total weight of the two components of the high viscosity component, and W_L is the weight % based on total weight of the two components of the low viscosity component; and the intrinsic viscosity $[\eta]$ is measured on a 96% sulphuric acid solution at 25°C.

Furthermore, the moisture content of the material should generally be adjusted to be not more than 0.05% by weight; specifically to not more than 0.05% for Nylon 6, and not more than 0.02% for Nylon 66.

The continuous filaments which have been forwarded to the receiver are succesively laid down on the surface in innumerable random loops. The receiver is an air-permeable sur-

face such as a net, perforated belt or perforated cylinder to permit the passage of the blown jet stream therethrough For manufacturing a sheet continuously, the deposit surface of receiver is moved at a constant rate

The "loops" as referred to herein, denote an arrangement of the filaments in which the filaments have helical crimps in a variety of shapes and sizes, forming arcs or closed curves.

When it is necessary to increase the efficiency of collection of the filaments on the receiver an air suction device is also provided beneath the deposit surface to suck the jet stream; or the filaments are electrically charged and the deposit surface is charged in the opposite polarity; or the filaments are electrostatically attracted with the deposit surface being earthed (or both suction and electrical attraction means are used together). Laydown should be performed so that the continuous filaments are entangled on the deposit surface at as many entanglement points as possible, and the entanglement points are distributed as uniformly as possible. It is desirable that the entanglement points are formed between spaced portions of the filament or between different layers of the filaments.

For achieving this object, the following conditions should be met:

(1) The average deposit area (the circular area formed by depositing filaments when the filaments being sprayed for a relatively long time to a constant position while the stream line of depositing jet has remained fixed) of the filaments should be large;

(2) The accumulated filaments should form a number of loops which have as large curvature as possible; are of relatively uniform sizes; and are distributed uniformly on the deposit surface. (For example, as shown in Fig. 2, the losely curved loops of Fig. 2*b* are better than the finely curled loops of Fig. 2*a*); and

(3) The adjacent layers of the web should be intertwined to some extent.

In order to equalize the thickness of the accumulated layer, the jet stream is traversed over the deposit surface.

If these conditions are not met, the desired properties such as stretchability and deformation recovery cannot be obtained. Furthermore (1) microscopic or macroscopic unevenness appear in the non-woven sheet, and (2) scalelike delamination occurs and the sheet is deformed easily by external force. This makes it impossible to deliver the accumulated web to subsequent steps.

Thus, the continuous filaments are laid down successively on the moving deposit surface to form a bulky web. Almost simultaneously with the laydown, the filaments are substantially completely released from tension, and further crimps grow in the web by the effect of retarded elastic shinkage. At this time, it is preferred that the accumulated web be allowed to stand or be heat-treated under such conditions that the web is relaxed within as short a period as possible after laydown, and allowed to shrink freely. Under these conditions, crimping of the filaments in the web proceeds further, and stable crimps which are fine and firm are obtained. These crimps are called secondary crimps.

Simultaneously with such further crimping, the rearrangement of the loops begins and entanglement between the filaments increases, with the result that the web as a whole shrinks and the basis weight of the web increases. Such a change brings about an increase in the stretchability and suppleness of the web and also a higher deformation recovery. Thus, there is obtained a stretchable polyamide non-woven sheet.

In order to maintain the accumulated web in the relaxed state, the web is removed from the deposit surface and treated by a treatment device such as a short loop dryer while suspended in space. Alternatively, the web is treated on the deposit surface or a wire belt surface having a reduced resistance to friction. This latter treatment produces little effect unless performed before post-treatment such as needle punching adhesive bonding or embossing. The method of treatment may be either standing or heat-treatment, but the latter is more advantageous for increasing productivity.

Most suitably, the web is heat treated for at least 10 seconds with heated air at 70 to 200°C or with saturated steam at 100 to 150°C. The individual filaments formed by subjection to such a treatment have helical crimps of extremely good stretch recovery which have 20 or more crimps per inch with an average helical radius of 0.1 to 0.5 mm.

As previously stated, the process of the present invention is intended to crimp a composite polyamide filament which is inherently difficult to crimp, by spinning the material into fine denier filaments and taking up the filaments at high speed. Accordingly, when the conventional spinning technique is used as such, the spinnability of the material is not so good. It is required therefore to find out optimum conditions for a continuous operation for prolonged periods of time, and to maintain these conditions strictly. Furthermore, when laying down the taken-up filaments on the deposit surface, conditions should be employed under which a number of entanglement points can be formed uniformly as mentioned above. It has been found that the most important factors which dominate these conditions are the distances between the spinning head and the pneumatic ejector and that between the deposit surface and the pneumatic ejector.

For example, when multifilaments are continuously taken up and deposited on the deposit surface by means of a pneumatic ejector, it is most suitable to apply a high speed pneumatic stream by the pneumatic ejector at a rate of at least 10,000 metres/min, and to adjust the distance between the outer surface of the spinneret and the tip of the yarn guide tube of the pneumatic ejector [the spinning distance which is shown as I in Figs. 1 (C) and (D)] to from 50 to 100 cm; and the distance between the jet outlet of the pneumatic ejector and the deposit surface [the laydown distance which is shown as III in Figs. 1 (C) and (D)] to from 70 to 140 cm. If the distance between the spinning head (spinneret) and the pneumatic ejector is shorter than the range specified above, the spinnability is improved, but the developability of crimp and the separability of the individual filaments are reduced; if it is longer, the results are reversed. If the distance between the pneumatic ejector and the deposit surface is shorter than the range specified above, the average deposit area is decreased and the effective entanglement points decrease in number. Accordingly the application of even a little external force on the accumulated sheet results in scale-like delamination: on the other hand, if this distance becomes longer, fine crimps are developed and the filaments are laid down in the finely curled and rounded state. Thus, a number of pill-like loops occur, and microscopic unevenness of the laid down web occurs. In this case, the number of entanglement points is small, and the resulting sheet has poor stretchability.

The spinning distance and laydown distance are considerably shorter than those employed in a machine for making ordinary sheets. Accordingly, these distances should be specially adjusted when the machine is used to produce the non-woven sheet in accordance with the present invention. Generally, it is usual that the position of the spinning head is fixed, and therefore, it is disadvantageous to require such distance adjustments. In order to adjust the differences between the original distances of the machine and those required for the present invention, there may be provided as shown in Figs. 1 and 3 circular tubes 3′ and 3″ having an inside diameter of 4 to 8 mm and a length of 300 to 2000 mm at the yarn guide tube inlet 6′ of the pneumatic ejector and the air jet nozzle outlet 7′. The provision of these compensating tubes serves to adjust the spinning distance and the laydown distance effectively, and makes it possible to operate continuously without adversely affecting factors such as spinnability, crimpability or lay-down property of the filaments. The circular tube 3′, besides compensating for the spinning distance, also serves to improve the spinnability.

The filaments which constitute the sheet of this invention have a fine denier of not more than 2 denier, and a residual elongation of not more than 100%, which value is smaller than conventional filaments which have been taken up by air. Accordingly, these filaments are pliable and tough. The filaments have very fine crimps which are at least 20 per inch and have an average helical radius of 0.1 to 0.5 mm, and have superior stretch recovery. The filaments are laid down in innumerable loops, which curve with a gentle curvature; and the number of small loops finely curled in the form of pills is relatively small. When such a state is quantatively expressed, the filaments form innumerable loops such that when a section of length *a* is defined at any chosen place of any one of said individual filaments, the ratio *c* of the loop length *b* of said filament present in said section to the length a ($c=b/a$) fulfills the following criteria:

(1) when $a=5$ mm, the probability of $c\geq 3$ is 20% or less; and

(2) when $a=20$ mm, the probability of $c\leq 2$ is 60% or more.

The method of defining the section of length *a* is illustrated in Fig. 4. When a section of 5 mm length is defined, a ratio $c\geq 3$ implies pill-like curling, but the probability of the existence of a portion containing such small loops is not more than 20%. When a section of 20 mm length is defined, a ratio $c\leq 2$ implies substantially straight or slightly curved loops. However, the fact that the probability of $c\leq 2$ is 60% or more shows that the loops exhibit gentle curves on the whole. By means of such a loop arrangement, a number of effective interlaced points are formed, and the resulting sheet has good stretchability and deformation recovery.

The method of measuring *c* of a given sheet may be either of the following:

(1) When the sheet has a thickness less than 1 mm: the sheet is placed on a black sheet of paper, cloth or plate, and its photograph (10×) is taken through a microscope under the irradiation of reflecting light; the value *b* is measured from the photo.

(2) When the sheet has a thickness of at least 1 mm: if the sheet is strippable, it is stripped to a thickness of about 1 mm, and the method (1) is applied; otherwise, the method (1) is applied after embedding the sheet in a resin such as an epoxy resin or poly(methyl methacrylate) and slicing it to a thickness of 1 mm.

A simplified method involves marking two small dots or cuts at distances of 5 mm and 20 mm respectively, gently picking up filaments having two dots or the cut filaments at both ends in the vicinity of the markings, and measuring the length of the loop between two dots or cut ends under tension sufficient to straighten it.

When a certain number (from 2 to 24) of multifilaments are taken up in accordance with the process of this invention without using any special spreading means, there can be obtained a stretchable non-woven sheet which contains a completely bundled portion wherein almost a constant number (from 2 to 24) of the filaments are arranged parallel and closely adjacent to each other, and form loops in this state, and wherein the proportion of filaments sharing substantially the same average crimp frequency, average helical radius, and crimp phase with at least one adjacent superposed filament, is not more than 20%. Perhaps because this sheet consists predominantly of bundled filaments, it has suppleness and stretchability and unique resilience (repulsive elasticity), all of these properties being useful as a substrate of artificial leather.

Where surface smoothness, uniformity and drapability are required, a non-woven sheet containing the bundled portion in as small an amount as possible may be utilized. This can be accompilshed by using an electrostatic separating method or other filament separating technique before or after the take-up of the filaments by a pneumatic stream.

Since the stretchable polyamide non-woven sheet so obtained has the constituent filaments lightly interlaced, it can be readily deformed by an external force. By utilizing this property, it can be used directly as a base cloth of a compress, for example. However, for most general applications, it is desired to avoid permanent deformation, and some bonding treatment is required for these applications.

To achieve this, the stretchable polyamide non-woven sheet so obtained is punched by such means as needle-punching or fluid-punching at a punching density of at least 50 punchings per square inch, preferably at least 100 punchings per square inch, thereby to give a three-dimensionally entangled, stretchable polyamide non-woven sheet in which entanglement points exist not only on the surface of the accumulated filament, but also in the thickness direction of the sheet.

Although non-woven sheet produced by the above-described process has excellent stretchability, suppleness and tensile strength, non-woven sheet having far superior tensile strength and deformation recovery is produced by needle-punching at high punching density, that is, 500 to 3,000 punchings per square inch: for such a punching density it is necessary that the denier of the filaments is not less than 0.8. When the denier of the filament is under 0.8 suppleness of the sheet is decreased by needle-punchings at high punching density because the density of sheet increases.

The result of needle-punching is also effected by the thickness of needle. When needle-punched using a thick needle of not more than 36 gauge, the filaments in the non-woven sheet are not entangled enough, and perforations are left on the sheet which lower its equality. Furthermore, when the non-woven sheet is needle-punched at a density of not more than 500 punchings per square inch, both tensile strength and dimensional stability of the obtained sheet are almost same as those of untreated non-woven sheet. On the contrary, when the non-woven sheet is needle-punched at a density of more than 3,000 punchings per square inch, the suppleness which the untreated web possesses disappears.

Fluid-punching is a process whereby a high speed jet stream of water, steam or air is blown against one or both surfaces of the sheet to perforate it and to cause the filaments to cohere. The individual filaments of these stretchable non-woven sheets may further be bonded by subjecting them to one or more of adhesive bonding, embossing and stitch-bonding treatments to form stretchable polyamide non-woven sheets having additional properties.

In order to improve the deformation recovery of the non-woven sheet further while utilizing its high stretchability and suppleness, one or more layers of a stretchable woven fabric or knitted fabric having a stretchability of at least 10% and a stretch recovery of at least 90% may be laminated on the untreated sheet or treated sheet of this invention described above. The stretchability and stretch recovery given above are measured in accordance with JIS L 1080—1967.

One bonding treatment method which can be applied while retaining the properties of the sheet of this invention is a method whereby the filaments are spot-bonded by a polyurethane type binder. The treated sheet so obtained can be utilized as artificial leather, above all leather for apparel, the chamois-like leather.

Some embodiments of the invention will now be described by way of Example.

EXAMPLE 1

Nylon 6 having an intrinsic viscosity (as measured on a 96% sulphuric acid solution at 25°C) of 1.18 and Nylon 6 having an intrinsic viscosity of 1.61 were co-spun at 265°C in a bimetal configuration. A composite nozzle plate with 24 holes was used, and the amount extruded of both the high viscosity and low viscosity components per hole was adjusted to 0.4 g/min. The spun filaments were taken up at a rate of 2400 metres/min by a high speed air stream using the apparatus shown in Fig. 1 (C), directly a two-component conjugated filament formation where two components having different viscosity are bonded, the boundary phase

being parallel to the direction of a fiber axis forwarded by the air stream, and laid down on a moving wire belt. The accumulated filaments were allowed to stand for 10 minutes in the relaxed state to form a non-woven sheet having the following properties.

TABLE 1

Thickness	8 mm
Filament denier	1.5 denier
Residual elongation of the filaments	76%
Number of crimps of the filaments	36/inch

TABLE 2

Tensile strength per unit thickness width	28.5 Kg/cm²
Drape coefficient	0.755

(These values were measured in accordance with JIS L-1079—1966)

The above results demonstrate that even without the bonding treatment, the non-woven sheet obtained had a high tensile strength, and was very supple for its thickness. When this sheet was heat-treated at 120°C by dry heat while allowing free shrinkage, the shrinkage in the width direction was less than 1%, showing superior dimensional stability.

EXAMPLE 2

The untreated sheet obtained in Example 1 was needle-punched at a density of 2000 punches/inch using a needle (gauge number 40). The thickness of the sheet was reduced to 5 mm. The sheet has the following properties.

TABLE 3

Property	Sheet of this invention	Conventional non-woven sheet
Tensile strength per unit thickness width	56.8 Kg/cm²	less than 30 Kg/cm²
Drape coefficient	0.729	less than 0.6

These results demonstrate that the sheet of this invention had a greater strength and suppleness than that of conventional non-woven cloth.

EXAMPLE 3

Nylon 6 having an intrinsic viscosity (as measured on a 96% sulphuric acid solution at 25°C) of 1.18 (low viscosity component) and a mixture of Nylon 6 having an intrinsic viscosity of 1.18 and Nylon 6 having an inherent viscosity of 1.61 (high viscosity component), which were both dried to a moisture content of 0.20% or less, were co-spun at 280°C into a bimetal configuration. A composite nozzle having 60 holes, each with a diameter of 0.3 mm was used and the amount per hole of each of the high and low viscosity components extruded was adjusted to, 15 g/min. Using the apparatus shown in Fig. 1 (D), each lot of six filaments was drafted by one of ten ejectors at a speed of 3460 metres/min, forwarded by jet stream, and laid down on a moving wire belt while each jet stream traversed in the width direction. The accumulated filaments were allowed to stand for 30 seconds, and then treated for 5 minutes with saturated steam at atmospheric pressure thereby to form a non-woven sheet having a unit weight of 100 g/m² and consisting of filaments each having a denier of 1.3, a residual elongation of 73%, and 45 helical crimps per inch.

A tube having an inside diameter of 5 mm and a length of 10 cm for compensating the spinning distance was provided at the upper part of the yarn guide tube of the air ejector, and a tube having an inside diameter of 6 mm and a length of 120 cm for compensation of the laydown distance was secured to the air nozzle outlet of the jet. The distance between the upper end of the spinning distance compensation tube and the spinning nozzle surface was adjusted to 70 cm, and the distance between the lower end of the laydown distance compensation tube and the deposit surface was adjusted to 100 cm. The laydown distance compensation tube was adapted to oscillate angularly by means of a ball joint.

The resulting non-woven sheet had a tensile strength, per thickness width, or 32 Kg/cm and a drape coefficient of 0.764, and had good suppleness and stretchability.

When a section of length a was defined in the resulting sheet, the probability of $c \geq 3$ was 2% for $a=5$ mm, and the probability of $c \leq 2$ was 85% for $a=20$ mm.

The sheet was needle-punched at a density of 200 punches/inch² using a standard needle (gauge number: 40). The treated sheet had a unit weight of 132 g/m². When the elongation and stretch recovery of the resulting sheet were measured in accordance with JIS L 1080—1067, the following results were obtained.

TABLE 4

	Widthwise direction	Lengthwise direction
Elongation *1	30%	26%
Stretch recovery *2	65%	62%

*1: constant load method, load 50 g/100 g/m^2, 5 cm
*2: exerting a load for 1 hour measured within 2 minutes after the removal of the load.

EXAMPLE 4

A knitted cloth having an elongation of 15% and a stretch recovery of 97% was disposed between two needle-punched sheets obtained as in Example 3, and the assembly was stitch-bonded at a density of 50 rows/10 cm using an Arachne machine. The resulting sheet had good stretchability, soft feel and drapability, and could find suitable applications as materials for bags, rugs and drapes.

EXAMPLE 5

The untreated sheet obtained in Example 1 was needle-punched at a density of 3000 punches/inch^2 using a needle (gauge number: 40). The needle-punched sheet was treated with an aqueous emulsion of silicone oil to form mosaic-shaped hydrophilic and water-repellent portions on the surfaces of the filaments. Then, the treated sheet was immersed in dimethylformamide solution of polyurethane to form a sheet in which the filaments were spot-bonded by the polyurethane. The sheet was raised to form an artificial leather like chamois leather, which had the following properties.

TABLE 5

	Widthwise direction	Lengthwise direction
Tensile strength strength (Kg/cm^2)	17	20
Elongation (%)	200	165
10% Modulus	0.8	1.2
Tear strength (Kg, the ring method)	11	14
Rupture strength (Kg/cm^2)	20	
Thickness (mm)	1.50	

EXAMPLE 6

Nylon 66 having an intrinsic viscosity of 1.20 and Nylon 66 having an intrinsic viscosity of 1.52 were co-spun at 280°C into a bimetal configuration. A composite nozzle having 24 holes was used, and the amount of each of the high and low viscosity components per hole was adjusted to 0.4 g/min. Using the apparatus shown in Fig. 1(D) (the layout of the individual members of the apparatus were the same as in Example 3) each lot of six filaments was drafted at a rate of 2400 metres/min by one of four air jet ejectors, forwarded by air, and laid down on a moving wire gauze. The laid-down filaments were heat-treated by dry heat at 150°C for 5 minutes to form a non-woven sheet having a unit weight of 200 g/m^2 and composed of filaments each having a denier of 1.5, a residual elongation of 69%, and 40 helical crimps per inch. The resulting non-woven sheet was embossed with embossing rollers having a woven pattern and held at 180°C, and the embossed surfaces were coated with foamed vinyl chloride resin to form a "vinyl leather" suitable for use as a chair covering, car seat or bag material. This sheet had superior stretchability, cushioning property and tear strength to conventional non-woven sheets which are based on a suede-finished woven cloth or knitted cloth.

WHAT WE CLAIM IS:—

1. A stretchable polyamide non-woven sheet comprising looped, continuous composite filaments composed of at least two different homopolyamides or homopolyamide mixtures each forming a distinct phase conjugated in a side-by-side or eccentric core-and-sheath configuration along the length of the filaments which are mutually entangled and have the following characteristics. (1) a denier size of not more than 2 denier; 2) a residual elongation of not more than 100%; 3) an average of at least 20 helical crimps per inch with an average helical radius of from 0.1 to 0.5 mm; and 4) loops such that when a section of length a is defined at any position along any individual filament, the ratio c, of the intrinsic length b of said filament in said section to the length a fulfills the following criteria:

(1) when a=5 mm, the probability of $c \geq 3$ is 20% or less,

and

(2) when a=20 mm, the probability of $c \leq 2$ is 60% or more.

2. A sheet as claimed in Claim 1, in which the filaments are additionally bonded at bonding points as a result of one or more bonding treatments selected from needle-punching, fluid-punching, adhesive bonding, embossing or stitch-bonding.

3. A sheet as claimed in Claim 2, in which the continuous composite filaments each have a denier of 0.2 to 2, the sheet has been needle-punched at a density of 500 to 3000 punches/inch^2 using a fine needle of not less than 36 gauge.

4. A sheet as claimed in any preceding Claim, in which a constant number of from 2 to 24 of the filaments in the looped state form a bundle in which they are arranged parallel and closely adjacent to each other, and the proportion of adjacent superposed filaments in the bundle in which the crimps have the same average frequency, average helical radius and phase, is not more than 20%.

5. A sheet as claimed in any preceding claim wherein the different homopolyamides have the same chemical structure but differ in their degrees of polymerization.

6. A sheet as claimed in any preceding claim, in which at least one homopolyamide is Nylon 6.

7. A sheet as claimed in any preceding claim, in which at least one homopolyamide is Nylon 66.

8. A sheet as claimed in Claim 5 or Claim 6 or 7 when dependent thereon, in which the degrees of polymerization and the weight proportions of the homopolyamides are selected within the ranges defined by the following equations:

$$1.10 \leq [\eta]_L \leq 1.40;$$

$$1.10 \leq \frac{[\eta]_H}{[\eta]_L} \leq 1.40$$

$$0.3 \leq \frac{W_H}{W_L} \leq 3;$$

wherein $[\eta]_H$ is the intrinsic viscosity of a high viscosity component, $[\eta]_L$ is the intrinsic viscosity of a low viscosity component, W_H is the weight % based on total weight of the high viscosity component, and W_L is the weight % based on total weight of the low viscosity component, the moisture content of these components being adjusted to not more than 0.05% by weight, the intrinsic viscosities being measured on a 96% sulphuric acid solution at 25°C.

9. A stretchable sheet comprising a sheet as claimed in any preceding claim and combined therewith at least one layer of a stretchable woven fabric or knitted fabric having a stretchability of at least 10% and a stretch recovery of at least 90%.

10. A stretchable sheet substantially as herein described with reference to any one of Examples 1 to 6.

11. A method of producing a stretchable non-woven sheet, which comprises co-spinning at least two homopolyamides or polyamide mixtures in a side-by-side or eccentric core-and-sheath configuration to form composite filaments, taking up the spun filaments at a rate of at least 1500 metres/min under conditions such that the filaments each have a denier of not more than 2 and a residual elongation of not more than 100% relaxing the filaments to develop loose primary crimps, forwarding the filaments by a pneumatic stream, depositing them on a receiver under conditions such that the continuous filaments become entangled to form a bulky web, and allowing the web to stand or heat-treating it in the relaxed state to develop fine and firm secondary crimps in the filaments, thereby forming a sheet in which the continuous filaments have at least 20 helical crimps per inch with an average helical radius of 0.1 to 0.5 mm.

12. A method as claimed in Claim 11, wherein the homopolyamides are two Nylon 6 or Nylon 66 homopolymers having different degrees of polymerization.

13. A method as claimed in Claim 11 or 12, wherein the homopolyamides are of the same chemical structure, and the degrees of polymerization and the weight proportions hereof are as defined in Claim 8.

14. A method as claimed in Claim 11, 12 or 13, wherein multifilaments spun from a spin head are drafted and taken up by the action of a high speed pneumatic stream at a rate of at least 10,000 metres/min through a pneumatic ejector, and then deposited on the receiver, the spinning distance between the surface of a spinneret of the spinning head and the tip of a yarn guide tube of the ejector being from 50 to 100 cm and the laydown distance between the jet stream outlet of the pneumatic ejector and the receiver being from 70 to 140 cm.

15. A method as claimed in Claim 14, wherein a circular tube having an inside diameter of 4 to 8 mm and a length of 30 to 200 cm is provided at the inlet or the jet stream outlet of the yarn guide tube of the air ejector to adjust the spinning distance or the laydown distance.

16. A method as claimed in any of Claims 11 to 15, wherein the bulky web on the receiver is heat-treated for 10 seconds or more with heated air or saturated steam at atmospheric pressure and at a temperature of from 70 to 200°C, while allowing it to shrink freely, in order to form the secondary crimps.

17. A method of producing a stretchable polyamide non-woven sheet substantially as herein described with reference to any one of Figs. 1(A) to 1(D) or to Fig. 1(D) in conjunction with Fig. 3.

18. A method of producing a stretchable polyamide non-woven sheet substantially as herein described with reference to any one of Examples 1 to 6.

19. A stretchable polyamide non-woven sheet when produced by a method as claimed in any one of Claims 9 to 18.

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1 423 213 COMPLETE SPECIFICATION
1 SHEET *This drawing is a reproduction of the Original on a reduced scale.*

FIG .1.

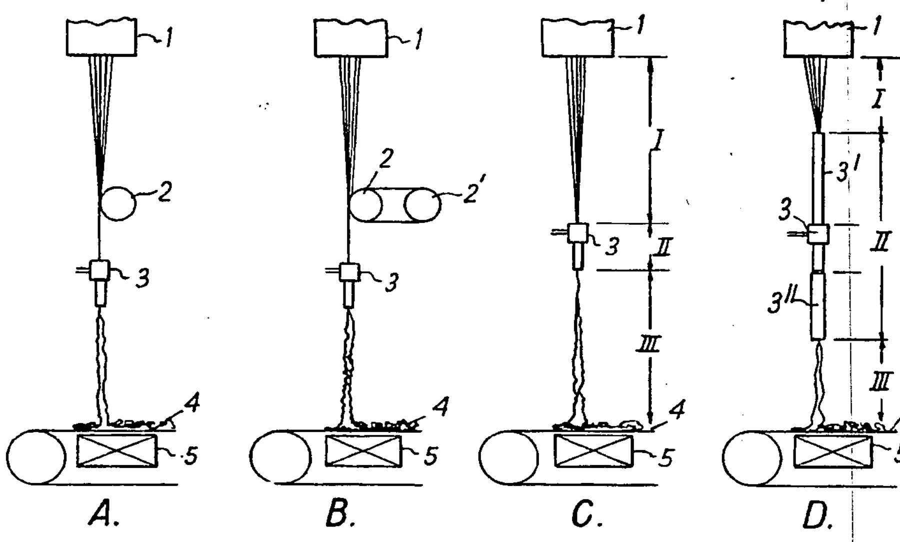

FIG.2.

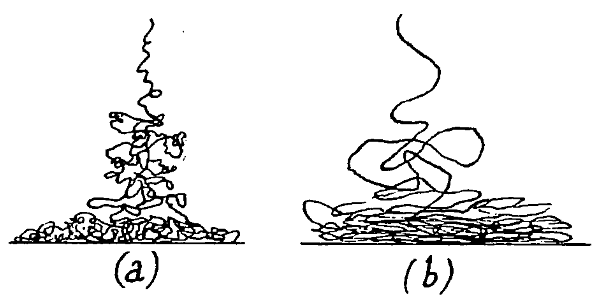

FIG.3.

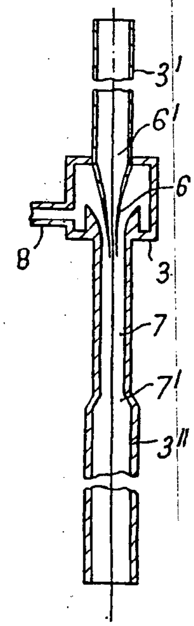

FIG .4.